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ESTIMATES OF BEFORE AND AFTER TAX SCALE ECONOMIES FOR A SAMPLE OF ILLINOIS CASH GRAIN FARMS*

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ABSTRACT

The primary purpose of this study was to investigate the degree of economies of scale existing, on a before and an after tax basis, for a sample of commercial Illinois farms. Results of the analysis indicate substantial scale economies both before and after taxes for this sample of cash grain producers. The cost curves were typically L-shaped, with major cost reductions occurring by the time farm size reached 500 tillable acres.

ESTIMATES OF BEFORE AND AFTER TAX SCALE ECONOMIES FOR A SAMPLE OF ILLINOIS CASH GRAIN FARMS

Farm size and the existence of economies of scale has long been a topic which has inspired much discussion, both within the ranks of agricultural economists and among the general citizenry. Periodically the scale economies question is addressed anew to determine if there have been any substantial changes in these size relationships. Such changes might well result (and often are alleged to result) from changed governmental policies, whether or not they specifically address the agricultural sector. Federal income tax laws represent one such group of policies which may have structural implications for agriculture. For example, such income tax provisions as investment tax credit, accelerated depreciation, additional first year depreciation, and the deductibility of interest expenses reduce the perceived after-tax cost of ownership of eligible capital and thus may stimulate the demand for such items.

These "tax shelters," however, may not be neutral with respect to the size of the farm business (Raup). The amount of the tax benefits received by a producer is determined in part by the individual's marginal tax rate, often a function of the size of the farm business. Thus, these laws may subsidize larger farm businesses to a greater degree than small farms, thereby creating economies of scale and encouraging the expansion of the farm business. Further, Reinsel and Reinsel suggest that tax policies also "alter the earnings of land through taxation of receipts from production, taxation of appreciation (capital gains), and taxation of real estate values," and thus impact on the price of land (p. 1096).

In this study cost curves for corn production are estimated for a sample of Illinois cash grain farms, both on a before and an after tax basis. Based on continuous farm records from 1975-79, regression techniques are utilized to indicate potential size economies and the extent to which such relationships are affected by certain federal income tax policies. To gain further insight into tax effects, results of a classification analysis of after tax costs on a whole farm basis are also presented.

Estimation Method and Data Sources

There are several methods which may be appropriate for the estimation of cost functions (Jensen). A common approach to cost estimation, and the one adopted for this study, is statistical analysis of accounting data on costs and output. An obvious advantage of this type of analysis is that it uses data from actual firms. Such data should provide much information concerning economies or diseconomies of scale associated with management or other factors. Further, tests of significance can be made allowing the researcher to express the degree of confidence of the estimates.

Ordinary least squares (OLS) regression will be the primary analytic tool used in this analysis. More specifically, analysis of covariance techniques will be applied because of the pooled nature of the data (a five year time series of cross-sectional data). This approach is valuable when viewing a relationship over a moving cross-section in that it considers all correlates of the individual cross-sections in exploration of the relationship. To independently estimate annual cross-sections may mean that unusual annual effects will not be controlled and the estimated relationship will be biased. A pooled analysis, however, may "average out" some of the extraneous information from individual cross-sections while recognizing the important temporal and cross-sectional relationships.

The data source used is a sample of individual records of cash grain farmers cooperating in the Illinois Farm Business Farm Management Association (FBFM). This is a federation of ten regional associations of farmers who, cooperatively with the University of Illinois Cooperative Extension Service and Department of Agricultural Economics, maintain a farm business records program. In 1979, there were 8,092 farms enrolled in the system.

The FBFM membership does not represent a random sample of Illinois commercial farmers. As such it falls short as a data source in that inference to the entire population of farmers cannot be made with statistical precision and confidence. However, the FBFM system is relatively unique in providing a set of accurate records for a relatively large number of producers over a multi-year period.

Because cash grain production is such an important component of agriculture in Illinois and the surrounding region of the United States, this type of producer was chosen as the focus of this analysis. In order to increase the consistency of the group under study, a homogeneous sample of producers was selected. To insure accuracy of the data, only farm records classified as usable by the FBFM fieldmen were used. Two additional restrictions were used in selecting the sample farms. The first required that corn, soybeans and wheat production must account for at least 95 percent of the crop acreage on each farm. Second, income derived from other sources was restricted to be less than five percent of total receipts.

Agricultural production is subject to year-to-year variation in average cost of production, due in large part to weather events outside the control of the farm operator. Preliminary analysis indicated that considerable variation in results occurred when the yearly cost data were analyzed separately. However, records for 168 cash producers, which satisfied the restrictions just cited, were available for each of the five years, 1975-79. Because the purpose of this effort was to investigate cost relationships on a longer run basis, this sample was analyzed as a time series of cross-sections. These farms varied considerably in size with three percent having less than 220 acres and six percent having more than 1,000 acres. Although all parts of the state were represented, the central region, the predominant cash grain region in Illinois, was most heavily represented.

The before tax cost curves were estimated to include explicit cost items as well as all implicit costs for each farm unit. Thus total costs per farm were the summation of expenditures for operating inputs, a cash rent charge for land, depreciation expenses on intermediate assets, an interest charge for all non-land capital, returns to family labor and a charge for management services.[1/] Details on estimation procedures for each of these cost factors are available in Batte. Average cash rent estimates were derived from unpublished data of the Illinois Cooperative Crop Reporting Service. Family labor was valued at a wage equivalent to that paid for hired farm labor. A management fee equal to that earned by professional farm managers was also charged.

One important aspect of this study is the estimation and inclusion of federal income taxes in an average cost estimation. This allows an evaluation of selected federal income tax policies with respect to their impact on average production costs. Unfortunately, although the FBFM records contain complete and accurate information concerning production costs, they do not include the amounts of income taxes paid by the producer.

There are several data items within the FBFM records, however, which allow construction of a reasonably accurate estimate of the tax liability. Farm income is accurately recorded as are most deductible farm expenses. A schedule of depreciable assets complete with acquisition dates (by month of purchase), value of items traded in, purchase price and depreciation, additional first year depreciation and investment credit claimed by the producer is also available. Missing information includes family size, personal deductions, the amount of off-farm income, and casualty losses which may be deducted by the individual. Thus several assumptions concerning factors such as family size, off-farm income and non-farm deductions are required because of missing data on the farm records.[2/]

For the before tax cost estimates, the farm (including both the tenant and landlord) was the unit of observation. For the after-tax analysis, an estimated tax bill (per bushel of production) for the farm operator only is added to the before tax estimate. Use of the operator only data is necessary because income taxes for several entities per farm are not readily comparable. Actual interest expenditures, rather than implicit interest charges, are used to calculate tax liabilities so that the impact of interest as a tax deduction, if any, might be discerned.

Results of the Statistical Analysis

One of the overall goals of the study was to estimate separate average cost relationships for corn, soybeans and wheat. This, however, required that total production costs be allocated between the three enterprises. This was accomplished by use of mixed estimation techniques involving estimation of regression coefficients subject to a set of stochastic equality constraints. An advantage of this technique is that a priori information can be incorporated into the estimation process and can then be modified by the statistical evidence provided in the sample data. The prior information for this analysis took the form of proportionality constants representing the cost relationships between the three crops for each year. These proportions were calculated from budget data included in the Illinois Farm Management Manual. The proportionality measures derived from the mixed estimation procedure were then used to allocate costs among the crops produced for each farm. The resulting cost estimates formed the dependent variables in the covariance analysis models.

The covariance analysis was repeated for each crop and for various dependent variables (before and after tax average cost based on various methods of depreciation calculation). Due to a lack of time and space, only the results for corn production will be reported. Similar results are available for both soybeans and wheat (Batte).

The measure of farm size chosen for this analysis was tillable acres. Although this is a measure of input usage, it was considered to be a good measure of potential business size. Because the main thrust of this study was to estimate the degree to which scale economies were present, it was considered important that various functional forms of the estimator be tested. Reciprocal, semi-log, and double-log transformations were tested as well as various combinations of the linear, reciprocal and higher power terms of tillable acres. For all three crops, the model judged most satisfactory was the reciprocal measure, indicating that an L-shaped cost curve is relevant for this sample of producers. The results of the covariance analysis are presented in Table 1.

Based on the estimated average cost relationship, the before-tax average costs of production (per bushel) at 250, 500, and 1,000 tillable acres are \$2.933, \$2.744, and \$2.649, respectively (for the southeast region). Hence farm size increases from 250 to 500 tillable acres are associated with an average cost decline of 18.9 cents per bushel whereas an increase from 500 to 1,000 acres would result in a decrease of only 9.5 cents. The before-tax average cost curve is presented graphically in Figure 1.

Examination of Table 1 reveals significant evidence of scale economies in each situation (i.e., the reciprocal size regression coefficient is highly significant, indicating a downward sloping average cost curve).[3/] A more interesting revelation comes, however, from a comparison of the before and after tax average cost relationships. For all depreciation calculation methods, the reciprocal size coefficient is reduced from that of the before tax cost relationship, indicating a flatter average cost curve (less scale economies) after tax. For example, consider a change from 250 to 500 tillable acres, employing the declining balance depreciation method in tax computation. This change results in a decrease of 19 cents per bushel in the before tax case, but only 15 cents per bushel in the after tax case.

Table 1. Comparison of the Estimated Average Cost Relationships for Corn Production Before and After Taxes Under Various Methods of Depreciation Calculation

Average Cost Relationship	Estimator[a,b]
I. Before Tax:	AC = 2.5548 + 94.6478[c] * 1/Tillable Acres
II. After Tax Analysis--IC Allowed:[d]	
"Actual" depreciation scenario	AC = 2.8098 + 76.878[c] * 1/Tillable Acres
Straight line depreciation scenario	AC = 2.747 + 73.9758[c] * 1/Tillable Acres
Declining balance depreciation scenario	AC = 2.7615 + 75.7507[c] * 1/Tillable Acres
III. After Tax Analysis--IC Disallowed:[d]	
"Actual" depreciation scenario	AC = 2.8625 + 75.3773[c] * 1/Tillable Acres
Straight line depreciation scenario	AC = 2.7806 + 72.1923[c] * 1/Tillable Acres
Declining balance depreciation scenario	AC = 2.8016 + 73.9554[c] * 1/Tillable Acres

[a] These functions represent the southeast crop reporting district of Illinois in 1979. Cost functions for other districts are available in Batte.

[b] The constant term includes the effect of other explanatory variables (which are held constant at their mean value for the sample). These variables are described in detail in Batte.

[c] Statistically significant at the 0.01 level of probability.

d The tax liability was estimated three ways. The "actual" depreciation scenario utilized a depreciation deduction equal to the depreciation in the farmers records. For the straight-line depreciation scenario, a straight line method was employed with machine and building service life assumptions of 7 and 20 years, respectively. The declining balance depreciation scenario was based on the declining balance method, and the same assumed service lives.

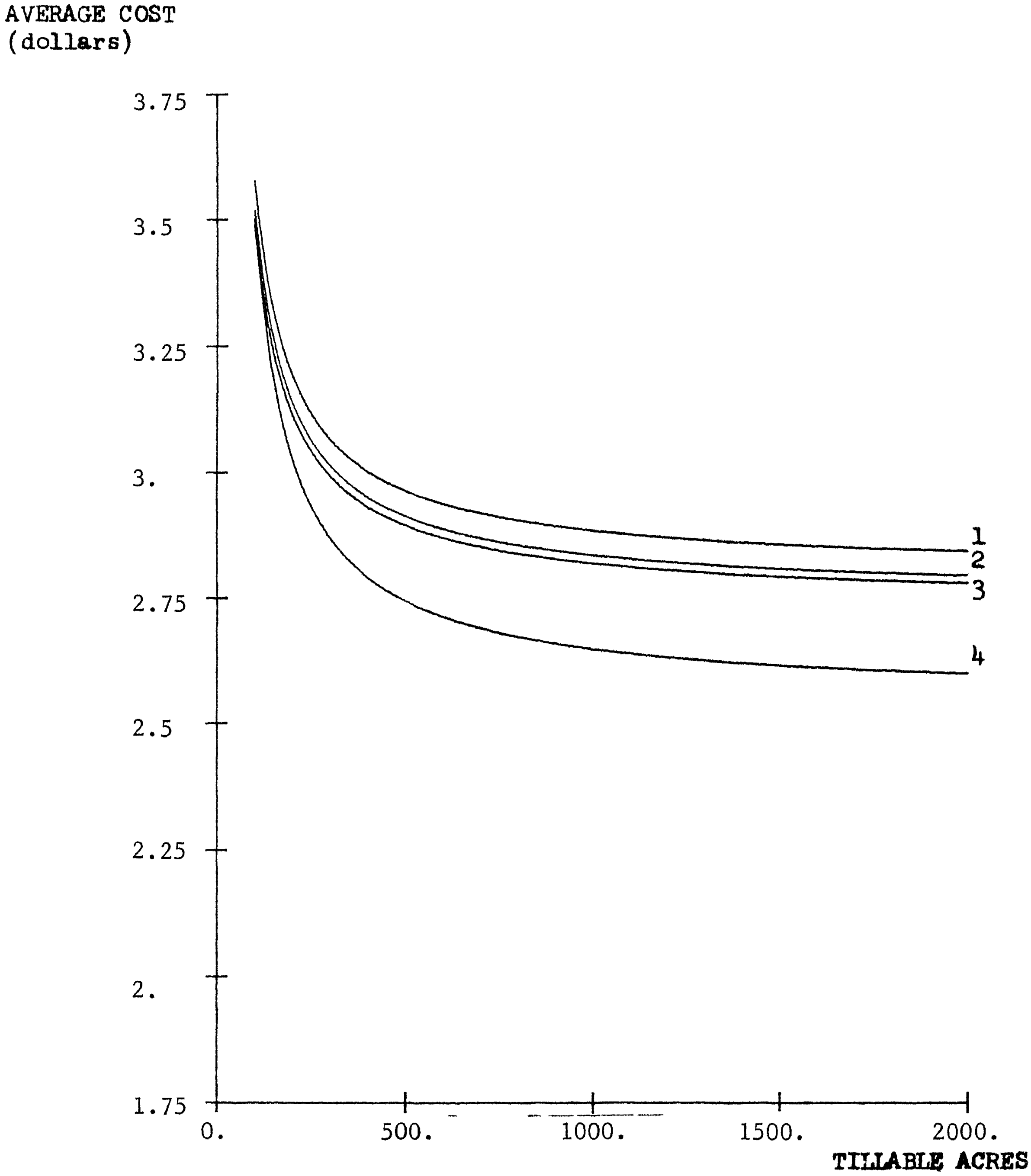

Figure 1. The Before- and After-Tax Average Cost Curves for Corn Production: The Southeast Crop Reporting District of Illinois, 1979.

1. After tax: "actual" depreciation scenario
2. After tax; declining balance depreciation scenario
3. After tax; straight line depreciation scenario
4. Before tax

A further comparison can be made between the after tax average cost "curves" estimated with and without the investment credit (IC) allowed. In each case, the removal of IC resulted in a larger size coefficient. This indicates that the IC allowance acted to reinforce the degree of scale economies present. That is, larger farmers were better able to utilize investment tax credits to offset tax liabilities than smaller farmers. A graphic comparison of the average cost curves, with and without IC, is presented in Figure 2.

An After Tax Classification Analysis

An alternative means of examination of the effects of taxes on the average cost relationships for farms of varying sizes is classification analysis. Costs, receipts and taxes can be expressed for the operator's share of the total farm business. (No attempt is made to allocate costs or taxes among the various farm enterprises.) Six size classes based on tillable acres are employed in the analysis. Although the size categorization was based on the land input, there is an increase in the operator's gross receipts with each size class increment which is roughly proportional to the size increase. Values of the other tax measures also increase with size (Table 2). As a consequence of pooling, the values reported are an average for the five year period.

To illustrate the relative changes in taxes that are associated with increased farm size, consider the following definitions: (1) the effective average tax rate is the quotient of the tax liability (after credits) divided by the operator's gross receipts, and (2) the effective marginal tax rate is the quotient of the change in tax liability (associated with a movement to the next largest size class) divided by

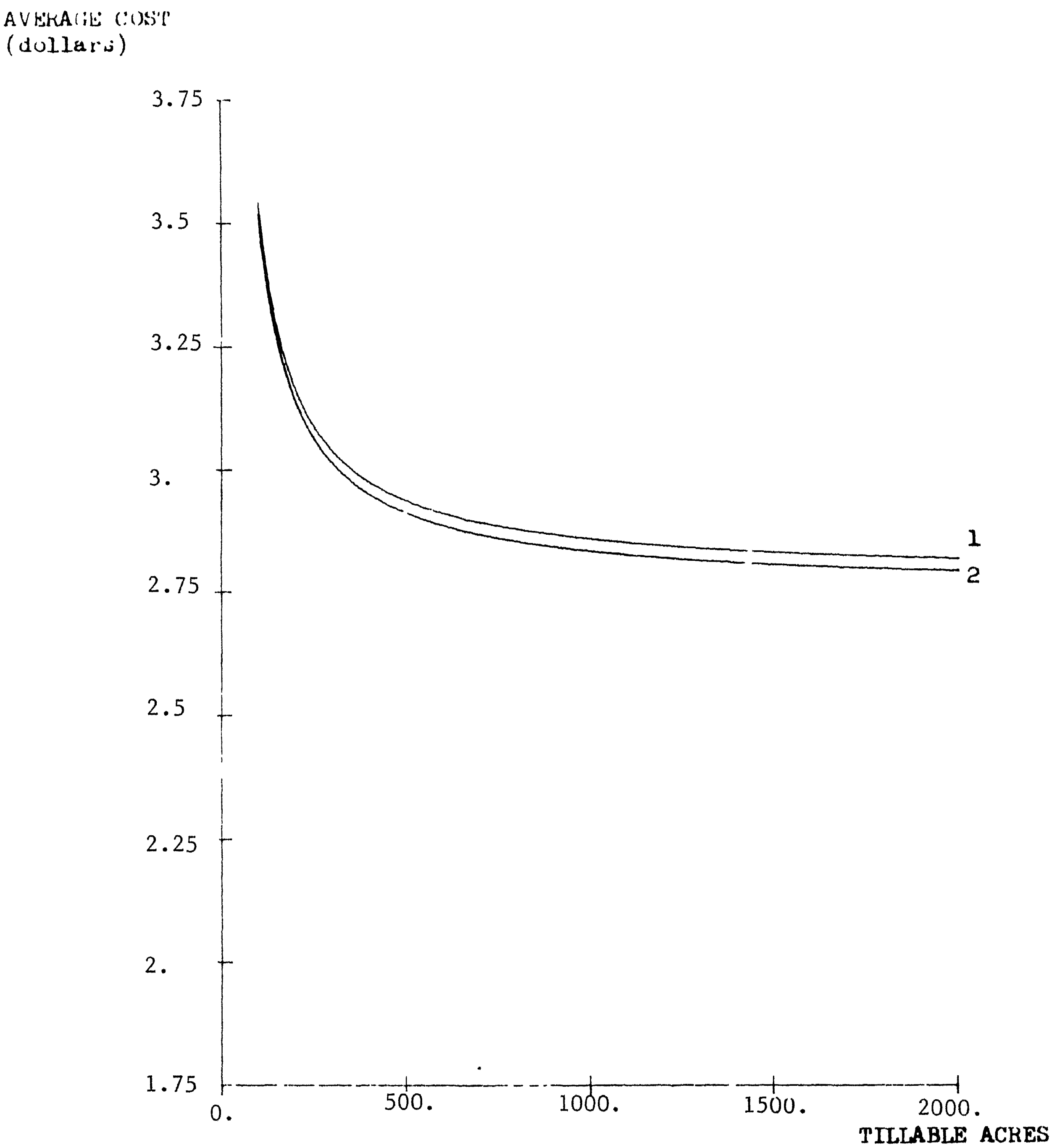

Figure 2. The After-Tax Average Cost Curve for Corn Production With and Without Investment Tax Credits Allowed; The Southeast Crop Reporting District of Illinois, 1979.

1. Declining balance scenario--IC disallowed
2. Declining balance scenario--IC allowed

Table 2. Classification Analysis of the Tax Liabilities for the Operator's Share of Farm Receipts

Measure	Under 200	200–400	400–600	600–800	800–1000	Over 1000
	SIZE CLASS (Tillable Acres)					
Number of Farms	20	246	338	148	41	47
Average Tillable Acreage	173	320	491	683	890	1,282
Operator's Income	34,286	56,982	84,684	110,542	147,695	219,941
With Zero Non-Farm Income:						
Depreciation[a] ($)	3,065	7,037	11,867	15,210	22,546	30,828
AFYD ($)	717	1,627	2,622	2,911	3,245	3,530
Tax Before Credits ($)	1,769	3,940	6,810	9,932	14,177	20,712
IC ($)	434	878	1,831	2,338	3,157	4,955
Tax After Credit ($)	1,335	3,062	4,979	7,595	11,020	15,757
Effective Average Tax Rate[b]	3.89	5.37	5.88	6.87	7.46	7.16
Effective Marginal Tax Rate[c]	—	7.61	6.91	10.12	9.22	6.56
With $20,000 Non-Farm Income:						
Depreciation[a] ($)	3,065	7,037	11,867	15,210	22,546	30,828
AFYD ($)	717	1,627	2,622	2,911	3,245	3,530
Tax Before Credits ($)	7,024	10,630	14,839	18,957	23,875	31,948
IC ($)	542	1,119	2,113	2,674	3,529	5,616
Tax After Credits ($)	6,482	9,512	12,726	16,283	20,345	26,332
Effective Average Tax Rate[b]	11.94	12.36	12.16	12.47	12.13	10.97
Effective Marginal Tax Rate[c]	—	13.35	11.60	13.76	10.94	8.29

[a] Assumes declining balance depreciation method.

[b] The quotient of tax after credits divided by gross income.

[c] The quotient of the change in tax after credits (associated with a movement to the next largest size class) divided by the change in gross income.

the corresponding change in gross income. These measures are not comparable to the corresponding terms of the Internal Revenue Service; the rates in this report are based on gross rather than adjusted gross income. They are intended only as a means of comparison across size categories.

To view the effects of farm size on taxes, let us first look at the case of zero non-farm income. The effective average tax rate tends to rise as farm size increases (Table 2). This provides some evidence that federal income tax rates are to some extent progressive, although the increases in average tax rates are relatively small.

The results are somewhat different when $20,000 of off-farm income rather than zero off-farm income is assumed. No longer is there a trend of increasing average tax rates with increased farm size as the lowest average tax rate occurs for the largest size class. Thus, it appears that the addition of a substantial contribution of off-farm income does not result in a progressive set of tax payments for these farmers.

Summary

It has been suggested that federal income tax policies are non-neutral with respect to their effects on farms of various sizes. This study was an attempt to address this question by means of statistical analysis of farm record data. The before tax cost relationships estimated provided substantial evidence of economies of scale, but no significant evidence of scale diseconomies. As such, these estimated cost curves fit the general description of an L-shaped curve. The degree of scale economies present was reduced slightly by the addition of the tax liability. Scale economies, however, were estimated to be greater with the inclusion of the investment tax credit.

Classification analysis was used to view tax impacts for various farm size classes. There was evidence that the tax rate was progressive if no off-farm income was considered, although the degree of progressivity was slight. In contrast assuming $20,000 per year in off-farm income led to a marginal tax rate which tended to decline as farms grew larger.

NOTES

1/ It is difficult to estimate a charge for land in the sense that land must be considered to be an input into two separate enterprises; cash grain production and an enterprise which may be termed speculative land ownership. Only a portion of the annual cost of land ownership should be charged the cash grain enterprises. The market determined cash rent should be an accurate estimate of the annual value of land in agricultural production. For this study, a cash rent function was estimated for Illinois for the study period and was used as the basis for the land change.

2/ Listed below are more specific assumptions required for the after tax analysis:

1. Each farm was assumed to be organized as a single proprietorship.
2. Four personal tax exemptions were assumed for each operator.
3. Non-farm income was initially assumed to be zero. A second analysis with an assumed non-farm income of $20,000 per year was also conducted.
4. It is assumed that all producers utilized the "standard deduction."
5. All receipts from the sale of capital items were treated as ordinary income, because of recapture of depreciation on machinery and equipment.
6. The 1979 tax laws and rates were assumed to have been in effect for all years of the study. It was felt that this would add consistency to the analysis in that an additional set of variables have been controlled.
7. Investment credit was allowed for structures such as grain bins as well as for all qualifying machinery.
8. Producers made maximum use of both AFYD and IC.

3/ Due to the formulation of the regression equation using the reciprocal of tillable acres as an independent variable, the slope of the average cost curve is:

$$- b/\ (\text{tillable acres})^2 ,$$

where b is the regression coefficient reported in Table 1.

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